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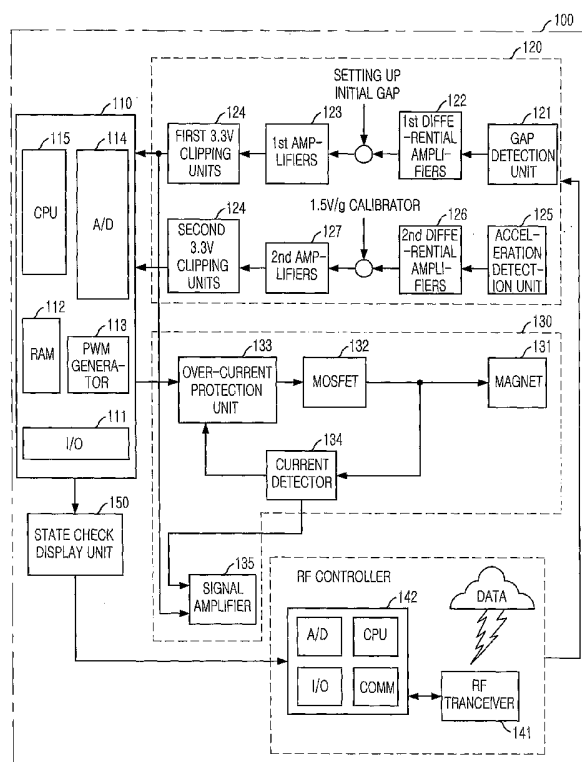
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[Continued on next page]

(54) Title: LEVITATION CONTROL APPARATUS FOR MAGNETIC LEVITATION TRAIN



(57) Abstract: The present invention provides a levitation control apparatus a magnetic levitation train, which includes a main operation unit digitally converting data inputted from the magnetic levitation train, performing pulse width modulation on the converted data, and transferring the modulated data to a state check & display unit to display a state of the magnetic levitation train, a signal conversion unit removing noise of analog signals inputted from a gap sensor and an acceleration sensor connected to the magnetic levitation train, setting up an initial gap by a variable resistor, and clipping the noise-removed signals to the main operation unit, a transformer over-current protection circuit unit cutting off a signal inputted to the main control unit if an over-current inputted to the main control unit occurs, an RF controller unit detecting a current flowing in the main control unit to make the detected current into a packet from of 23-bytes, transferring the packet to the main control unit to be used for a levitation control, and allowing the main control unit not to use a PWM signal if the current is equal to or greater than a predefined over-current, and a state check & display unit connected to the RF controller unit, controlled by the main control unit to check abnormality of RF reception, and displaying a result of the checked test. Accordingly, the occurrence of malfunction due to the hardware simplification is reduced and other peripheral circuits can sufficiently provide their functions as the protection circuit of the magnetic levitation train as well.



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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Levitation Control Apparatus for Magnetic Levitation Train

TECHNICAL FIELD

The present invention relates to a levitation control
5 apparatus a magnetic levitation train, in which the same
system of the magnetic levitation train is employed overall,
in which a structure failing to essentially match with that
of the real magnetic levitation train is configured to fit
the characteristics of the magnetic levitation train, and
10 by which a test can be performed with the same performance
of the magnetic levitation train.

BACKGROUND ART

Generally, a rapid transit railway is opened for
15 traffic to develop a public traffic means with the purpose
of supporting the national economy base. Accordingly, life
patterns have been changed as well as life paradigms. For
instance, the National Capital region is expanded.

The rapid transit railway, which employs a wheel
20 system, reduces its contact and the like in aspect of
operating the wheel system, prepares various systems
including a railway, a train, and the like such as a
rotation of the train to fit its speed, and operates its
control system to fit its high speed. Yet, limitation is
25 put on the high-speed train using the wheel system and
there are various problems caused by the rapid transit
service. Moreover, to overcome the problems, various kinds
of technical know-how and operational know-how are needed.

A magnetic levitation train, which is expected as one
30 of the next generation solutions, needs to solve its own
problems for test such as an excessive expense, wide test
area occupancy, and the like. Currently, the magnetic
levitation train system is operated by such an advanced
country as Japan, U.S.A., Germany, China, and the like for
35 test equipments and limited regions only. And, it is still
regarded as reckless to commercialize the magnetic

levitation train system despite the excessive expense and the risk proportional to a national-wide scale that combines the entire country as a one-day life zone.

In order to secure the performance and reliability, a levitation control and propulsion system configuring the magnetic levitation train system needs to be sufficiently tested to enhance controller hardware and software reliability. However, there are too many risks and danger in testing the real system variously. And, the various tests need vast expenses as well. Hence, it is preferably recommended to perform a test using a reduced or miniaturized system.

DISCLOSURE OF THE INVENTION

15 TECHNICAL PROBLEM

Even though miniature models imitating the configuration and structure have been prepared in Korea, the reduced model having the basic principle of the magnetic levitation train applied thereto has never been prepared. Hence, it is unable to substantially perform a simulation test of the magnetic levitation train.

TECHNICAL SOLUTION

An object of the present invention is to provide a levitation control apparatus a magnetic levitation train, in which a hardware configuration including an electromagnet generating a levitation force of an intake type magnetic levitation system, a gap sensor detecting an interval signal between a rail and a train, a levitation controller, and a levitation power supply device (chopper) is equivalent to that of a real magnetic levitation train but differs in size only, in which a miniaturized linear motor of a three-phase linear form is installed as a propulsion system, and in which a propulsion power supply device (inverter) employs an operational system of the real magnetic levitation train.

Another object of the present invention is to provide a levitation control apparatus a magnetic levitation train, in which the magnetic levitation train is miniaturized to be provided with the same performance of a real magnetic levitation train to enable a same result of testing the real magnetic levitation train, in which the magnetic levitation train is capable of being fully functional, in which a hardware structure of the magnetic levitation train failing to match with that of the real magnetic levitation train is configured with a circuit fitting the characteristic of the magnetic levitation train, and by which a protection circuit for system simplification and endurance enhancement is provided.

15 ADVANTAGEOUS EFFECTS

Accordingly, the present invention acquires high-speed operational processing capability of DSP using the controller as hardware of the magnetic levitation train based on DSP. And, various functions are built in the processor to reduce a size of hardware and the occurrence of malfunction due to the hardware simplification. Moreover, other peripheral circuits can sufficiently provide their functions as the protection circuit of the magnetic levitation train as well.

25 BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

In the drawing, FIG. 1 is a block diagram of a levitation control apparatus a magnetic levitation train according to one embodiment of the present invention.

<brief description of principal cord part of figures>

levitation controller 100
 main operation unit 110
 input/output unit 111
 RAM 112
 5 pulse width modulation generator 113
 analog/digital converter 114
 CPU 115
 signal conversion unit 120
 gap detection unit 121
 10 1st and 2nd differential amplifiers 122, 126
 1st and 2nd amplifiers 123, 127
 first and second 3.3V clipping units 124 and 128
 acceleration detection unit 125
 over-current protection circuit unit 130
 15 electromagnet 131
 MOSFET 132
 over-current protection unit 133
 current detector 134
 signal amplifier 135
 20 RF controller unit 140
 RF receiver 141
 RF controller 142
 state check & display unit 150

25 BEST MODE FOR CARRYING OUT THE INVENTION

To achieve these and other advantages and in
 accordance with the purpose of the present invention, as
 embodied and broadly described, a levitation control
 apparatus a magnetic levitation train according to the
 30 present invention includes a main operation unit digitally
 converting data inputted from the magnetic levitation train,
 performing pulse width modulation on the converted data,
 and transferring the modulated data to a state check &
 display unit to display a state of the magnetic levitation
 35 train, a signal conversion unit removing noise of analog
 signals inputted from a gap sensor and an acceleration

sensor connected to the magnetic levitation train, setting up an initial gap by a variable resistor, and clipping the noise-removed signals to the main operation unit, a transformer over-current protection circuit unit cutting off a signal inputted to the main control unit if an over-current inputted to the main control unit occurs, an RF controller unit detecting a current flowing in the main control unit to make the detected current into a packet form of 23-bytes, transferring the packet to the main control unit to be used for a levitation control, and allowing the main control unit not to use a PWM signal if the current is equal to or greater than a predefined over-current, and a state check & display unit connected to the RF controller unit, controlled by the main control unit to check abnormality of RF reception, and displaying a result of the checked test.

BEST MODE FOR CARRYING OUT THE INVENTION

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings.

FIG. 1 is a block diagram of a levitation Control Apparatus a magnetic levitation train according to one embodiment of the present invention.

Referring to FIG. 1, a levitation controller 100 includes a main operation unit 110, a signal conversion unit 120, an over-current protection circuit unit 130 of a transformer, an RF controller unit 140 controlling the magnetic levitation train by wireless, and a state check & display unit 150.

The main operation unit 110 includes an input/output unit 111, a RAM 112, a pulse width modulation generator 113, and analog/digital converter 114, and a CPU 115.

The main operation unit 110 digitally converts data inputted from a signal converting unit to a packet signal, performs pulse width modulation on the converted data, and

then transfers the modulated data to the state check & display unit 150 to display a state of the magnetic levitation train.

The input/output unit 111 controls the data mutually inputted/outputted to/from the signal conversion unit 120, the over-current protection circuit unit 130 of the transformer, and the RF controller unit 140 and provides a protocol suitable for transmitting/receiving the inputted/outputted data.

The RAM 112 is a flash RAM provided with a capacity of about 32K words x 16-bits and stores the information necessary for a control and the inputted/outputted data therein.

The pulse width modulation generator 113 receives the data and then performs pulse width modulation on the received and digitalized data. In doing so, if the digitalized data exceeds a reference, the pulse width modulation is not allowable.

The analog/digital converter 114 converts an analog signal, which is inputted from the signal conversion unit 120 and the RF controller unit 140, to a digital signal.

The CPU 113 is a 32-bit device based on a DSP CPU core, in which the flash RAM 111 is built. The CPU 115 is provided with a pulse width modulation (PWM) function, a 10-bit A/D converting function, a serial communication input/output function, a watchdog timer module, and the like, thereby simplifying the control circuit.

The levitation controller 100 has a shape of a rack in which a slot for loading the main operation unit 110 therein can be built, thereby facilitating the assembly or disassembly for a test. The main operation unit 110 is provided with an operation speed of 40MIPS, sixteen A/D channels, eight PWM (pulse width modulation) channels, a data memory of 2.5K words, and a programmable memory of 32Kbytes, and is capable of executing levitation control algorithm smoothly and multiply.

The signal conversion unit 120 includes a gap detection unit 121 connected to the magnetic levitation train to detect a gap between the magnetic levitation train and the railway and an acceleration detection unit 125
5 detecting an acceleration of the magnetic levitation train.

The signal conversion unit 120 is an analog signal processing unit processing signals inputted from a gap sensor and an acceleration sensor. A noise of the detected signal is preferentially removed by a differential
10 amplifier, an initial gap is set up by a variable resistor, and clipping is performed within a range of 3.3V requested by the A/D converter 114 of the main operation unit 110.

The gap signal detected via the gap detection unit 121 of the signal conversion unit 120 is amplified by a
15 first differential amplifier 122. The amplified signal is by a first amplifier 123 again with the setup of an initial gap value. The amplified signal is clipped by a first 3.3V clipping unit 124 to clip to the voltage of 3.3V and is then transferred to the main operation unit 110.

20 The acceleration signal detected via the acceleration detection unit 125 of the signal conversion unit 120 is amplified by a second differential amplifier 126. The amplified signal is amplified by a second amplifier 127 again with the setup of the acceleration value according to
25 1.5V/g. And, the amplified signal is clipped by a second 3.3V clipping unit 128 to clip to the voltage of 3.3V and is then transferred to the main operation unit 110.

The over-current protection circuit unit 130 of the transformer is a chopper control unit. Once over-current
30 occurs, the over-current protection circuit unit 130 turns off a MOSFET transistor as a signal is cut off by a NAND gate. In doing so, PC922 is used for the electrical insulation between a power unit and a control unit.

Specifically, in the over-current protection unit 130
35 of the transformer, a current detector 134 preferentially detects a supply current that is supplied to an

electromagnet 131.

The current detector 134 transfers the corresponding information to an over-current protection unit 133. The signal detected by the current detector 134 is amplified by
5 a signal amplifier 135 to be transferred to the main operation unit 110. The over-current protection unit 133 recognizes the gap and acceleration signals received from the main operation unit 110 and a current value of the electromagnet inputted via the signal amplifier 135, and
10 adjusts the current value of the electromagnet 131. This means to change the current value of the electromagnet 131 according to the gap value and the acceleration value. Thus, the current value is repeatedly fed back to be inputted so that the current value is varied, whereby a constant speed
15 and a constant gap can be sustained.

Meanwhile, in the RF controller unit 140, the current flowing in the main control unit 110 is detected as a voltage form by a current detection analog photo-coupler. The current detection analog photo-coupler is a device
20 capable of measuring a maximum peak current of 35[A] and a regulated current of 25[A] according to arrangement of an input terminal. In this case, by considering the current supplied to the electromagnet 131, the circuit is configured to measure a maximum current of the device. And,
25 the measured current is A/D-converted to be transferred to the main control unit 110 to be used for a levitation control. Moreover, if the measured current exceeds an over-current set up by a comparator, a PWM signal cannot be used.

The RF controller unit 140 makes the data of the gap sensor and the acceleration sensor and the data of a current state of the miniaturized magnetic levitation train into 23-byte packets and then transfers the packets to a monitoring PC.
30

The RF controller unit 140 includes an RF receiver
35 141 and an RF controller 142. The RF receiver 141 receives data from a magnetic levitation train system. The data

received from the magnetic levitation train may be gap information, acceleration information, or other magnetic levitation train information required for operating the magnetic levitation train. The data are controlled by the main control unit 110 so as to be smoothly received from the signal conversion unit 120 by wireless.

The RF controller 142 includes an analog/digital converter, a CPU, an input/output unit, and a communication control unit.

And, the state check & display unit 150, which is connected to the RF controller unit 140, is controlled by the main control unit 110 to check abnormality of RF reception. Moreover, the state check & display unit 150 displays the test results to enable a tester or operator to recognize the operational state of the magnetic levitation train.

INDUSTRIAL APPLICABILITY

The present invention relates to a levitation control apparatus a magnetic levitation train, in which the same system of the magnetic levitation train is employed overall, in which a structure failing to essentially match with that of the real magnetic levitation train is configured to fit the characteristics of the magnetic levitation train, and by which a test can be performed with the same performance of the magnetic levitation train, thereby the occurrence of malfunction due to the hardware simplification is reduced and by testing protection circuit of the magnetic levitation train it can be apply to the real magnetic levitation train.

WHAT IS CLAIMED IS:

1. A levitation control apparatus a magnetic levitation train, comprising:

a main operation unit 110 digitally converting data inputted from the magnetic levitation train, performing pulse width modulation on the converted data, and transferring the modulated data to a state check & display unit 150 to display a state of the magnetic levitation train;

a signal conversion unit 120 removing noise of analog signals inputted from a gap sensor and an acceleration sensor connected to the magnetic levitation train, setting up an initial gap by a variable resistor, and clipping the noise-removed signals to the main operation unit 110;

a transformer over-current protection circuit unit 130 cutting off a signal inputted to the main control unit 110 if an over-current inputted to the main control unit occurs;

an RF controller unit 140 detecting a current flowing in the main control unit 110 to make the detected current into a packet form of 23-bytes, transferring the packet to the main control unit 110 to be used for a levitation control, and allowing the main control unit 110 not to use a PWM signal if the current is equal to or greater than a predefined over-current; and

a state check & display unit 150 connected to the RF controller unit 140, controlled by the main control unit 110 to check abnormality of RF reception, and displaying a result of the checked test.

2. The apparatus of claim 1, the signal conversion unit 120 comprising:

a gap detection unit 121 detecting a gap between the magnetic levitation train and a railway;

an acceleration detection unit 125 detecting an acceleration of the magnetic levitation train;

differential amplifiers 122 and 126 amplifying gap and acceleration signals detected via the gap and acceleration detection units 121 and 125, respectively;

5 amplifiers 123 and 127 setting the amplified signals to an initial gap value and an acceleration value according to 1.5V/g to amplify, respectively; and

first and second 3.3V clipping units 124 and 128 clipping the signals amplified by the amplifiers 123 and 127 by a voltage value of 3.3V, respectively.

10

3. The apparatus of claim 1, the over-current protection circuit unit 130 comprising:

15 a current detector 134 detecting a current of an electromagnet 131 providing a magnetic force to the magnetic levitation train;

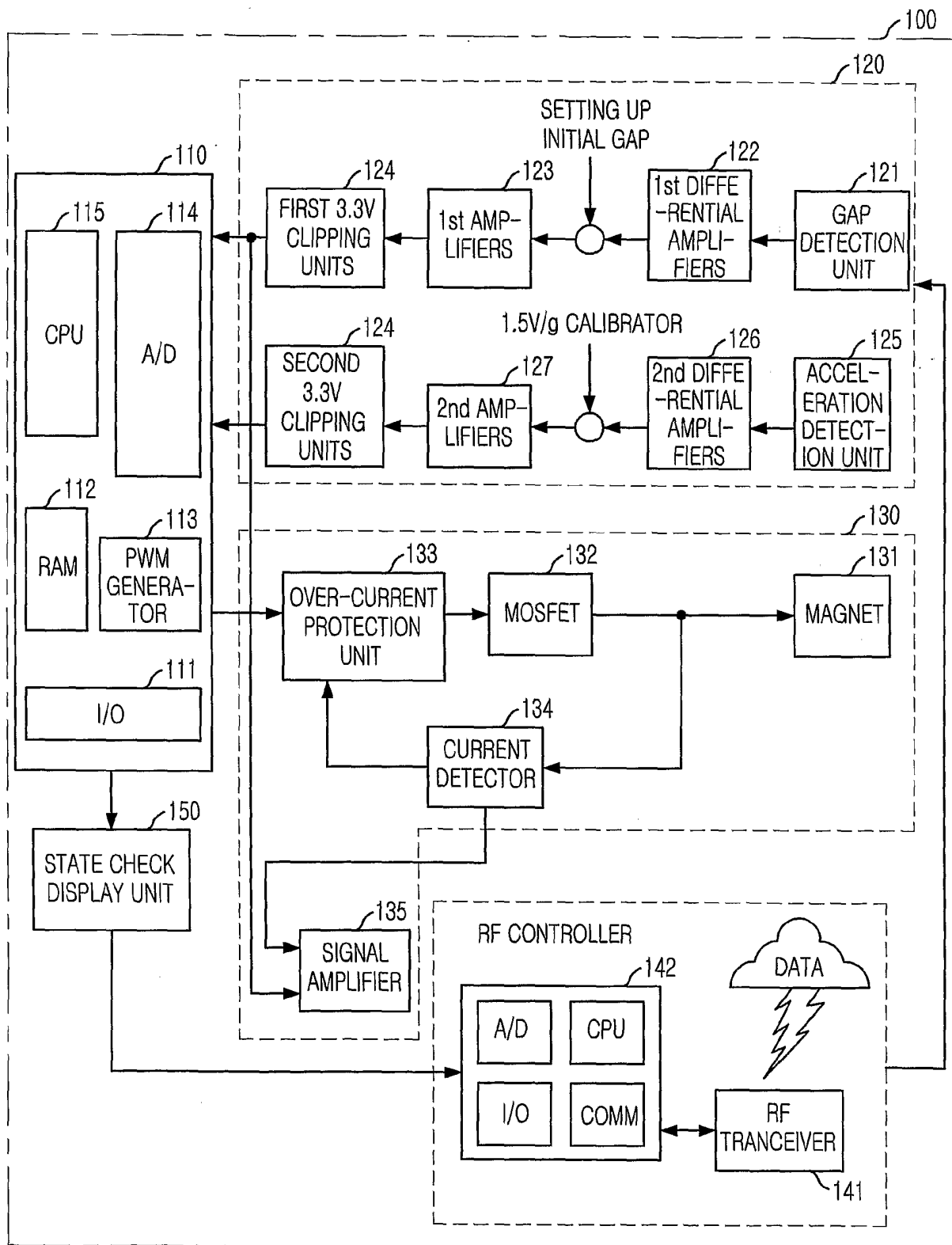
an over-current protection unit 133 recognizing gap and acceleration signals received from the main operation unit 110 and a current value of an electromagnet inputted via a signal amplifier 135 amplifying the detected current
20 to transfer to the main operation unit 110; and

a MOSFET 132 adjusting the current value of the electromagnet 131 under a control of the over-current protection unit 133.

25 4. The apparatus of claim 1, the RF controller unit 140 comprising:

an RF receiver 141 receiving data from a magnetic levitation train system; and

30 an RF controller 142 receiving a command inputted from the main controller 110 and performing packet processing on data received from the RF receiver 141.

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FIG. 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2004/003557

A. CLASSIFICATION OF SUBJECT MATTER**IPC7 G01M 17/08**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7 G01M 17/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Patents and applications for inventions since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKIPASS "levitation" "train" "control" "gap"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KIM KUK-HUN, KIM CHOON-KYUNG "Development of levitation control apparatus for magnet levitation train" In 'MACHINE AND MATERIAL', 1997, Vol.9, No.2, pages 33-45. See the entire document	1-4
A	JP 14-333020A(EBARA CORP, EBARA DENSAN LTD) 22 NOV 2002 See the entire document	1-4
A	JP 63-228906 A(SUMITOMO ELECTRIC INDUSTRIES) 22 SEP 1988 See the entire document	1-4
A	US 5477788 A(KABUSHIKI KAISHA TOSHIBA) 26 DEC 1995 See the entire document	1-4



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2004/003557

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